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THE USE OF FLAMING AND MECHANICAL METHODS FOR WEED CONTROL IN COTTON

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SUMMARY

1. Do not start flaming before cotton plants have a one-fourth-inch-diameter stem at the ground line; or are 8 to 10 inches tall.

2. For good results, flaming should be done when weeds and grasses are in the seedling stage.

3. Weeds escaping flaming must be hoed. Beware of leaving large, dry weeds in the cotton row which will ignite and burn cotton at succeeding flamings.

4. Flaming will not eradicate large, established weeds.

5. In the test trials, late annual grasses were controlled until layby, but became dense thereafter.

6. Four flamings reduced the water grass by infestation by 35 to 40 per cent, based on a late-season count.

7. Flaming has reduced broadleaf infestations by 90%.

8. Flaming has not controlled Johnson grass.

9. A reduction in hoeing costs was recorded. How much this saving can be in fields badly infested with broadleaf weeds is not known.

10. Flaming costs about 90¢ per acre per application when operated with cultivator.

11. Proper burner adjustment in relation to drill row is imperative.

12. Burners must not be directly opposite each other on the same row.

13. Effectiveness of various adjustments should be checked on small plots before using on a larger scale--especially field speed and operating pressure changes.

14. Flaming has neither reduced nor increased yields.

15. Continued dirting reduces the broadleaf population, and probably the number of cotton plants.

16. Better weed control with flaming has improved cotton grades for machine picking.

17. Flame cultivation is not a cure-all, but you may expect assistance from it.

THE USE OF FLAMING AND MECHANICAL METHODS FOR WEED CONTROL IN COTTON

by E. R. Holekamp 1/

PART A: EXPERIMENTAL PROCEDURE AND RESULTS

The use of flaming to supplement mechanical methods for weed control in cotton is not a new subject, but receives much attention because of the existing and increasing weed infestations and the expense of good weed control. Some good results have been obtained with flaming at the Marana Farm of the University of Arizona. Mechanical methods include a wide variety of equipment, but this report includes only those that were used.

Weed control investigations with mechanical cultivation and mechanical cultivation supplemented with flaming for the past two years at the Marana Farm have been primarily concerned with the period from the cotton seedling to layby time. During this period there were two distinctive periods of weed control: one extending from cotton seedling stage to the first post-planting irrigation, and the other during the period of rapid growth and frequent irrigations. There are also weed control problems before planting and after normal layby, which will not be included in this report.

Experimental work at the Marana Farm has been on fair-sized plots. Each individual plot consisted of 4 rows, one-quarter mile long or approximately 0.4 acre, giving us operations very similar to those on farms. Most data presented in this report will be based on plots of this size--except that for weed control counts. Weed control data was taken from the two center rows of the plots at three locations, near the center and 200 feet in from each end. The weed sampling areas were equivalent to 0.01 acre per row.

Preliminary investigations, prior to our work at Marana included various equipment. Early investigations using the rotary hoe were discouraging in heavy working soils and, therefore, we discontinued their use. (There is an apparent interest in this tool in the Yuma area.) Essentially, it is a high speed tool that is used in small cotton. Another machine, the rotary cross harrow, was tried and showed some promise. Investigations included all types of mechanical equipment in use at that time.

After flame cultivation was condemned by farmers before 1950, our early investigations with a hand-pushed model proved that flaming was a help in the control of annual weeds.

With these preliminary considerations, the following weed control practices in experimental plots on the Marana Farm were established in 1953.

A. No flaming. Light dirting, using frequent mechanical cultivations with one dirting of the drill to leave a low row profile.

B. No flaming. Heavy dirting, using frequent cultivations with continued dirting of the drill row. This treatment resembles common practices in Arizona.

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C. Flamed. Heavy dirting, cultivation same as B.

D. Flamed. Light dirting, cultivation same as A.

The equipment used in these tests for mechanical cultivation included sweeps, cultivator disks and the flame cultivator. Early cultivations, prior to the first post planting irrigation, were all alike and required three cultivations using the cultivator disks set close to cut away from the row; leaving only a six to eight inch band of undisturbed soil along the cotton plants to reduce the required hoeing to the minimum. Three 14-inch sweeps were used to cultivate middles between the rows and to fill the furrow left by the disk. The sweeps had sufficient overlap to cut all weeds. For the third cultivation, built-up furrowing sweeps were used in the middles to open the irrigation furrow. The fourth cultivation was similar to the first three except that the disks were set one-inch further apart. In 1954, flaming was begun at this time on treatments C and D.

For the fifth cultivation, the cultivator disks were reset to throw dirt towards the rows to cover small weeds that were germinated by the irrigation. Generally, the disks were set 17 inches apart on the leading edge and 10 inches apart on the trailing edge. Flaming began with this cultivation in 1953. Cultivation thereafter for the heavy dirting used similar settings making only minor adjustments to fit the profile. The use of cultivator disks for the light dirting treatment was discontinued after one dirting. The total number of cultivations was nine in 1953 and eight in 1954. Three to five flamings were used as needed. Treatment D in 1953 differed slightly from that followed in 1954. One deviation was used in this program. The rotary cross harrow was used in place of the first flaming. The rotary cross harrow is an aggressive piece of equipment and should only be used on raised beds to permit trash to fall out. Operating speed was 3.3 mph and cotton ranged from 8 to 18 inches tall. An average of 206 cotton plants per acre were uprooted or severely damaged. The damage to cotton was more severe in cloddy soil. Weed control was good.

The flame cultivator was mounted on the tractor with the regular cultivator to keep operational costs at a minimum. The flame cultivator was operated at speed of 3.0 to 3.4 mph. Gas pressure was maintained at 30 psi for all the tests. Burners were set at an angle of 45° from horizontal and 8 to 10 inches from the center of the row so that the flame stroke 2 to 3 inches from the base of the plants on the burner side of the row. Flaming was usually started with the first or second cultivation one or two weeks after the first post planting irrigation. This irrigation usually brings on many annual weeds. At this time cotton was generally 8 to 10 inches tall and had sufficient stalk diameter to withstand the heat of flaming. It may be well to add that hand hoeing was continued in these plots for control of escaping weeds.

Results of these tests show that flaming has not decreased or increased the cotton yields. (Table I). Flaming has shown that some improvement in grade of machine picked cotton can be expected due to better weed control obtained in these plots. These grades are based on the first picking of seven to eight bales from the flamed and unflamed plots each year. The grade improvement was small in 1953, and amounted to about 1/2 grade for 1954. All these plots were machine picked and 89.2% of all the cotton was harvested. No specific differences in machine picking efficiencies were noted for the high and low beds or for flamed plots.

Counts of cotton plants taken after the first picking in the fall, show the highest population and lowest percentage of skips for the light dirting treatment for the two years. Lowest population was maintained for the heavy dirting supplemented with flaming. The severest reduction amounted to 15 per cent of the stand or 3,000 plants per acre with heavy dirting. Yields were not effected by this plant reduction. (Table I).

Table I. Yields of Cotton and Grades of Cotton Obtained with Different Cultivation Practices for Weed Control

Treatments	Year	Machine Picked Yields of Seed Cotton, lbs. per acre	Average Grade for 1st Picking, USDA Grade Index[1]
Light dirting without flaming	1953	2865	99.8
	1954	2968	90.7
	Avg.	2917	95.3
Heavy dirting without flaming	1953	2895	99.8
	1954	2908	90.7
	Avg.	2902	95.3
Heavy dirting with flaming	1953	2865	100.5
	1954	2927	94.9
	Avg.	2896	97.7
Light dirting with flaming	1953	2820	100.5
	1954	2978	94.9
	Avg.	2899	97.7

[1]SM = 104, M = 100, SLM = 94 and LM = 85.

A count of weeds after the second flaming and sixth cultivations shows that heavy dirting certainly is effective in weed control at this time for annual broadleaf weeds and to a small extent on annual grasses. (Table II). It reduced broadleaf population by 85% from those in the light dirting treatment. Flaming in the heavy dirting treatment reduced the broadleaf weed infestation 87% of that in the heavy dirting treatment without flaming and flaming reduced the broadleaf weed infestation by 98% in the light dirting treatments. The broadleaf weed infestation was predominantly annual morning glory, with some puncture vines, careless weeds and ground cherry. The count at this time also shows some control of annual grasse by flaming.

Another check of weed control at the end of season shows that good control on the broadleafs carried on through the late season after layby; at this time broadleaf population in the flamed plots was 85 to 90% of those in the unflamed plots. The control of annual water grasses appears to be very low. It was observed that these late annual grasses were extremely prevalent where the stands were skippy, but grasses in the flamed plots were not quite as dense or large as those in check plots. Late season cultivation is indicated here. Our layby both years was the end of July. At that time, it rained frequently and kept the ground wet under dens foliage, making it impossible to continue cultivation.

Table II. Weed Control Obtained, Cotton Stand Maintained and Labor Required for Hoeing Weeds with Various Cultivation Practices.

Treatment	Year	Number of Flamings Applied	Cotton Plants per 0.01 acre	Skips over 2 ft. long, % of row	Weed Counts, Weeds per 0.01 acre				Hoeing Labor, Twice over, hours per acre	
					After 2nd Flaming		After 1st Picking			
					Broad-leaf Weeds	Annual Grasses	Broad-leaf Weeds	Annual Grasses		
Light dirting only	1953	0	228	1.5			15.0	14.0		
	1954	0	231	9.2	176.0	1.9	31.6	10.4	9.7	
	Avg.		230	5.3			23.3	12.2		9.1
Heavy dirting only	1953	0	203	4.6			2.0	21.0		
	1954	0	212	12.7	27.0	0.5	18.2	7.8	8.6	
	Avg.		208	8.6			10.1	14.4		
Heavy dirting + flame	1953	4	197	5.4			0.2	14.0		
	1954	4	203	11.4	3.6	0	2.8	6.8	7.5	
	Avg.		200	8.4			1.5	10.4		7.1
Light dirting + flame	1953	3	213	1.5			0.2	9.0		
	1954	5	211	11.9	3.1	0	1.4	11.4	6.6	
	Avg.		212	6.7			0.8	10.2		

An attempt to obtain the effect of these practices on hoeing labor required was made. Difficulty was experienced in keeping the crews moving in light weed infestations on the long narrow plots. The labor requirements were obtained for two hoeings after the flaming and dirting program was begun. The two hoeings show an average labor requirement of 9.1 man-hours per acre for the unflamed plots and 7.1 man-hours per acre for the flamed plots. Hoeing records were also kept on eleven-acre areas, flamed and unflamed within the same field. Labor requirements for a single hoeing on the unflamed plot amounted to 7.6 man-hours per acre and only 2.7 man-hours for the flamed plot. A saving of 4.9 man-hours per acre was obtained for a single hoeing after 3 flamings.

Flaming has not proven effective on Johnson grass. It is present at planting and persists through the season. Timely flaming after hoeing helps to retard its growth. This was evident in the last cultivation in late July, hoed Johnson grass in the unflamed plots required stopping in the plots to remove the debris from the sweeps. In the flamed plots, this was not necessary. One precaution - dry, chopped Johnson grass thrown at the base of cotton plants by the cultivator will ignite and burn cotton.

Another observation was that defoliation in the falmed rows was much better, because morning glory did not entangle the cotton with dense foliage preventing good penetration of defoliants.

What about the cost of flaming? Average fuel consumption was 4.5 gallons per acre per flaming. Fuel costs in deliveries of 500 gallons or over averages about 1 cents per gallon, thus fuel costs are 72 cents per acre per flaming. Allowing 18 cents per application for overhead costs of the flame cultivator, our flaming costs were 90 cents per acre per flaming.

Analyzing the costs and returns from these operations for 1954, a net profit of $9.74 per acre was obtained using the minimum of advantages noted and discussed. (Table III). If the labor savings observed in the 11-acre plot are used, the cost of flaming are more than offset by savings in hoeing costs alone.

Table III. Expected Returns, Weed Control Costs and Net Gain per Acre as Obtained with Flame Cultivation of Cotton for 1954

	Flamed Plots	Check Plots
Expected returns:		
Lint yield for first picking, 2330 lbs. seed cotton, 35% lint turnout, lbs.	800	800
Average lint value (see Table I), Gov't. loan value, cents per lb.	32.73	31.25
Gross return per acre	$261.84	$250.00
Increased value of cotton	$ 11.84	
Weed control costs:		
8 cultivations @ $1.25 each (custom rate)	$ 10.00	$ 10.00
4-1/2 flamings @ $.90 each	$ 4.05	
3 hoeings during period, labor @ $.65 per hour, 1.5 x time from Table II	$ 6.92	$ 8.87
Total weed control costs	$ 20.97	$ 18.87
Increased weed control costs	$ 2.10	
Net increase in expected returns	$ 9.74	

PART B: PROCEDURE FOR FLAME CULTIVATION IN COTTON

Excellent control of annual weeds in cotton has been obtained by supplementing regular cultivation with the application of flame to the drill row.

Intensity of Heat

The heat applied is controlled by the amount of pressure used and the forward speed. Increasing the pressure applies more heat and decreasing field speed would also increase heat intensity. For average conditions, a pressure of 30 pounds per square inch and field speed of 3 mph are satisfactory. Pressure should not be increased or speed decreased unless it is indicated that more heat is necessary to kill weeds.

The effects of flaming are not always immediately visible, but can be observed several hours after flaming. Close examination behind the flame cultivator will show that leaves of small weeds and grasses are withered and limp. Burning the lower leaves of the cotton plant does not affect the plant. Occasionally a slight yellowing of cotton leaves will be noticed after flaming but disappears soon.

Flame is applied, not to burn out weeds, but to cause the liquid in plant cells to expand and rupture the cell walls and thus kill the weeds. This principle works best on small annual-weed seedlings. Larger and more mature weeds require more intense heat and are difficult to kill with flaming. Cotton plants should be 8 to 10 inches tall and have a stem about $\frac{1}{4}$ inch in diameter to withstand the heat of flamir

Cost of Operation

Present flame cultivators use a butane-propane fuel because it burns clean with intense heat. Four and one-half gallons of fuel per acre were used for each flaming while operating at 3 mph and 30 pounds gas pressure.

Fuel for flaming costs 70 to 72 cents per acre at these rates. If an allowance of 18 cents an acre is made for the overhead cost of the flame equipment, the fuel and equipment costs will amount to approximately 90 cents per acre for eacl flaming, exclusive of charges for tractor and operator.

Flame cultivation can be applied simultaneously with regular cultivation or as a separate operation. Simultaneous application requires a slight modification of the rear cultivator gangs, but has the advantages of fewer trips through the field and a saving in operating costs.

The Equipment

Fuel Tank

The tank should be large enough to hold a half day's supply of fuel (propane-butane). This should be at least a 100 gallon tank for a four-row cultivator. The tank should not be mounted too far to the rear of the tractor nor should a much larger tank be used, because it will lighten the front end of tractor making steering difficult. The tank should be equipped with a suitable refill valve, a pressure balance line valve, an 85% full valve, a liquid level gauge, a pressure gauge, a safety valve, and a liquid withdrawal valve.

Fuel Vaporizer

A hot water heat exchanger supplied with hot water from the tractor engine is well adapted for vaporizing the liquid fuel after it is withdrawn from the tank. Vapor withdrawal from the tank is not satisfactory; usually it results in the loss of pressure as the more volatile propane has been drawn off. Hot water vaporizers supply sufficient heat to change the liquid fuel to a vapor and to keep fuel lines and regulator from freezing.

Pressure Regulators

Tank pressures vary with air temperatures from 120 to 200 pounds per square inch and is too high for proper burner operation. A pressure regulator is required to reduce this high tank pressure to the operating pressure of 30 pounds per square inch. Pressure regulators perform satisfactorily when installed near the inlet to the vaporizer. Pressure regulators built into the vaporizer are excellent.

Pressure Gauges

A pressure gauge on the vapor side of the pressure regulator or vaporizer is necessary for proper regulation of gas pressure to the burners. Another gauge should be installed on the tank to observe tank pressure and is helpful by indicating that the tank is almost empty by a rapid decrease of pressure.

Control Valve

A quick opening control valve in the gas line between vaporizer and burners allows the gas to be shut off for turns and for short stops. A small hole drilled in the quick opening valve permits enough gas to pass through to the burners to maintain a small pilot light which will not burn the cotton.

Burners

Flat burners of the U.S.D.A. design have given excellent results and have been found superior to the round type of burners used on early models of flame cultivators. This burner produces a wide, thin flame that provides a longer exposure of weeds to the flame. The design of this burner is shown on another page. If burners are to be built in a local shop, care should be used to build burners to specifications.

Operation and Adjustment of Flame Cultivators

When to Flame

Flaming of cotton can begin when the smallest cotton is 8 to 10 inches tall and the stalk is about $\frac{1}{4}$" in diameter and can continue until lay-by or until bolls open. The best time to apply flaming to the drill row is 7 to 10 days after an irrigation when weed seedlings first appear, but before they make much growth. Two flamings between irrigations spaced a week apart may be needed in heavy annual weed infestations.

Setting of Burners

For proper application of flame, the burners must be adjusted and set with care. Two flat burners staggered on opposite sides of a row are required. The burners are set at an angle of 45 degrees from the horizontal. The flame end of the burner should be set 6 to 8 inches above the bed and 9 to 10 inches away from the cotton plant. With this setting the flame is 10 to 12 inches long and strikes the bed 2 to 3 inches from the cotton plant. The accompanying sketches show proper application. Usually final burner adjustments are made in the field to get proper burner position. The few plants burned while stopping to make field adjustments is less damaging than improper application with poor results over a large acreage.

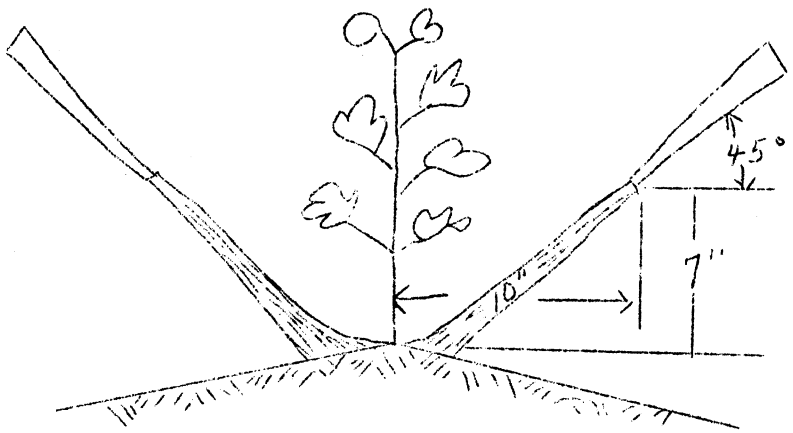
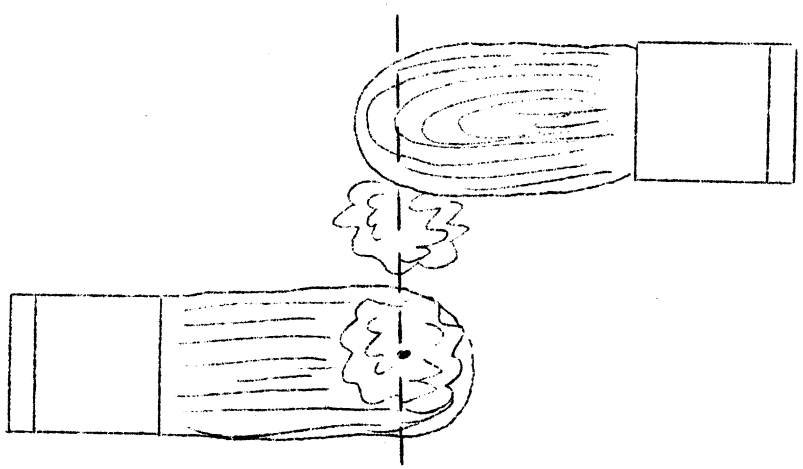
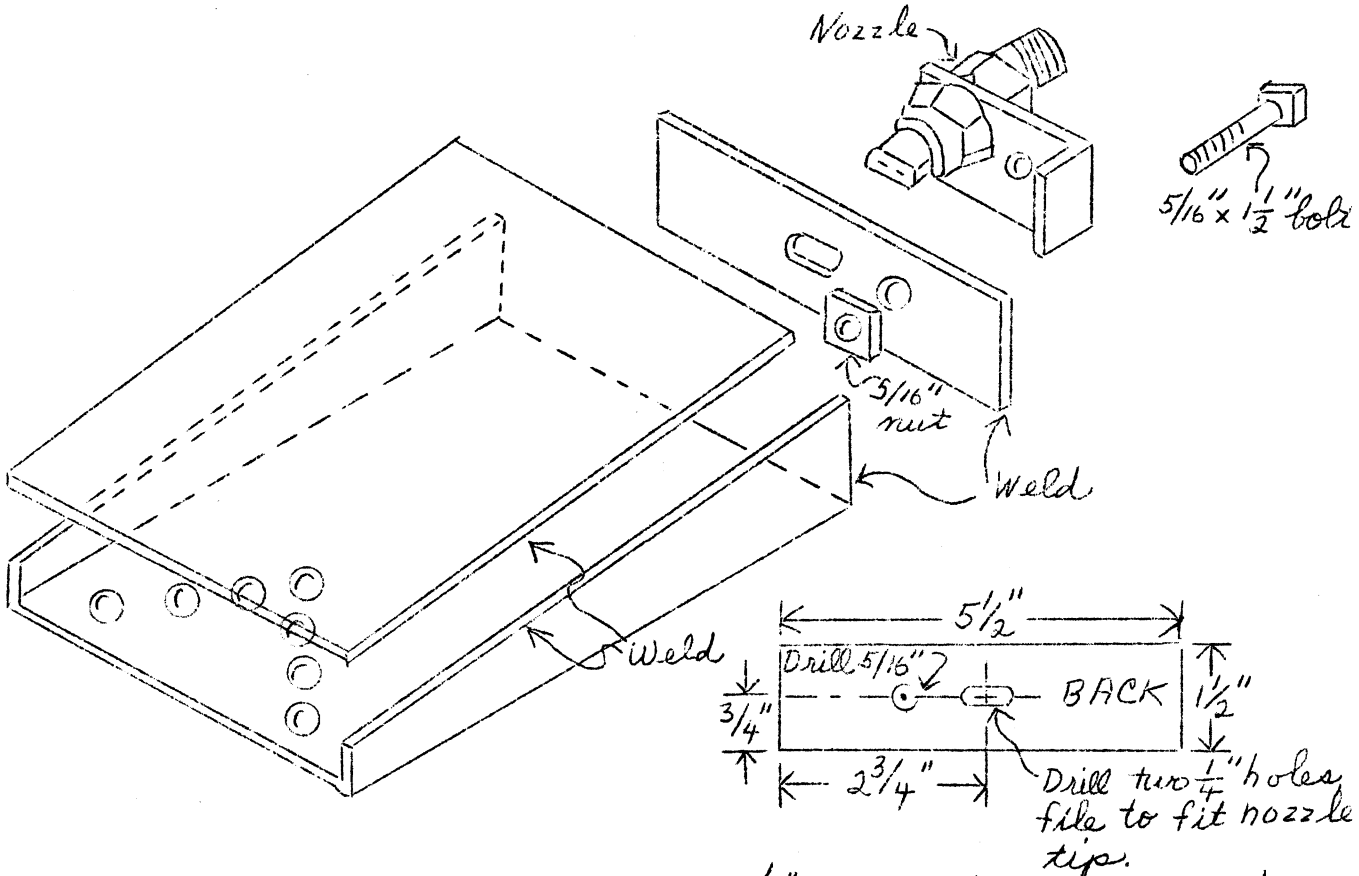
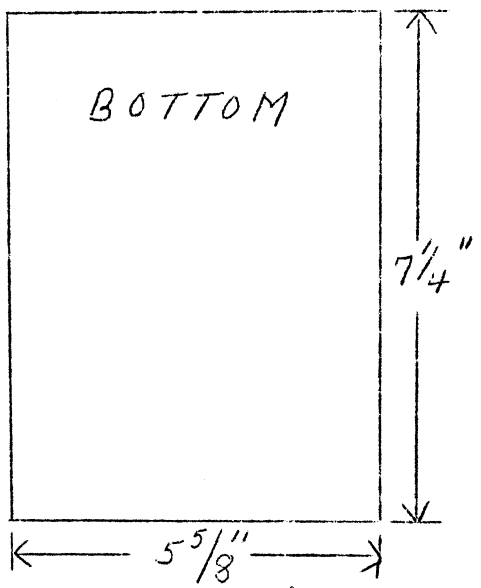


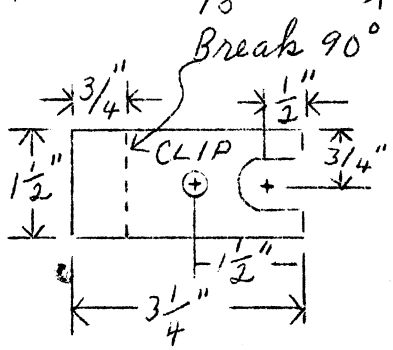
Diagram showing position of burners

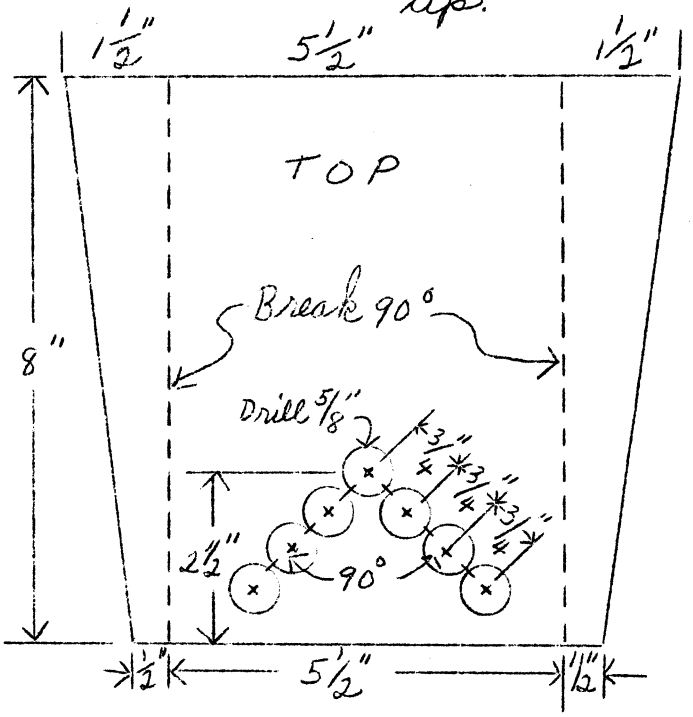


Top view showing staggered position of burners









Burner is fabricated from 10 gauge sheet iron. Use spraying systems "Teejet" ¼" male spray nozzle with 2-2502 orifice tip and 50 mesh screen.

Note: The burner design is by J. K. Jones, U.S.D.A. Cotton Mechanization Project, Stoneville, Mississippi.